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14. ABSTRACT Biocontrol of wild oats (Avena Fatua), one of the world's most serious weeds, is largely unexplored. We investigated crown rust disease as a potential control agent for wild oats on San Clemente Island. The results showed that application of crown rust lowers the competitive ability of wild oats while raising that of stipa, a native grass. Crown rust may be an effective biocontrol agent when used in a suite of management tools.

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FINAL REPORT

Grant #: N000149610920

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GRANT TITLE: Control of Wild Oats, *Avena fatua*, on San Clemente Island Using the Fungal Leaf Pathogen *Puccinia coronata*, Causal Agent of Crown Rust of Oats.

AWARD PERIOD: June 1996 - June 1999

OBJECTIVES:

a. Biological control of wild oats on San Clemente Island with the oat pathogen *P. coronata* and subsequent enhancement of the native flora on this island.

b. Development of technology for the biological control of weeds with rust pathogens and its transfer to and implementation on other military bases and agricultural situations infested with wild oats.

c. Determination of the impact of early-season deployment of the rust on populations of wild oats and stipa (the dominant native grass).

d. Acquisition of sufficient weather data from the island and correlation with naturally occurring infection periods.

e. Determination of the involvement of the alternate host in generating genetic variability within the pathogen species. Molecular and pathological characterization of *P.coronata* on San Clemente Island and on other channel islands where *P.coronata* exists in the absence of the alternate host.

APPROACH: Two initial scoping and collecting trips to SCI catalogued problem weeds, some of their pathogens and identified an appropriate pathogen for use in biocontrol.

The island was randomly surveyed during two entire growing seasons along with intense environmental monitoring to understand the epidemiology of the pathogen. Subsequently, the virulence spectrum of the pathogen was determined and compared to the mainland.

To determine the feasibility and practicality of using the identified pathogen, experimental plots were established on the island. In the second year, we selected for a low temperature tolerant strain of *P. coronata.* This low temperature mutant was used in conjunction with the original strain in the field trials. In both years, crown rust was deployed early, before the onset of natural infection. These field experiments continued through the end of the third year.

In addition to the experiments carried out on San Clemente Island, we performed two greenhouse studies. The first, host-range testing, was carried out to ascertain the safety of the biocontrol agent. The

second, a competition study, was undertaken to assess how well the native stipa grasses compete with wild oats under conditions of epidemic rust.

ACCOMPLISHMENTS: Two of the most serious invasive and exotic weeds of SCI are *Avena fatua* and *Avena barbata*. These weeds are better known as wild oats to farmers throughout the world. We determined that several endemic plant diseases on the island might be useful in controlling wild oats. One of these disease agents, *Puccinia coronata,* is a cereal rust disease that attacks both species of wild oats. The island races of this rust are very similar to mainland California and Baja, California races of crown rust. On the island, no alternate host for the fungus has been verified, and our data suggest that the rust is capable of over-summering on the island, allowing it to infect wild oats in the late fall after the rainy season initiates seedling growth.

The results of field trials over the three-year period were variable. In year one and two, the field trials showed that early application of fungal spores to target grasses did result in early onset of infection. Analysis of reproductive output of the wild oats in these plots revealed that some components of yield and reproduction of inoculated plants were lower than the fitness of plants from control plots. However, in the third year, extremely dry conditions on the island precluded early infection and spread of the pathogen altogether.

We determined that different biotypes of the fungus may behave differently, indicating that success of this agent could vary depending on which isolate is used to initiate infection. For example, one late season (1996) isolate was extremely fast in terms of its latent period (time required from inoculation to sporulation). We now have detailed information on rust isolates, rust epidemiology, and detailed weather data from San Clemente Island for three consecutive years.

We tested the host range of the fungus against several native and exotic grass species tested on the island. No sporulation was observed on *Bromus spp., Phalaris spp., Hordeum spp.,* and *Nassella pulchra.* Sporulating pustules of crown rust were observed on a number of *Lamarkia* plants, indicating that this species is susceptible to the oat specific form of crown rust. Since *Lamarkia* is also an introduced species these results should not interfere with the safety this biocontrol agent on San Clemente Island.

We undertook a competition study between wild oats and stipa in which we established varying densities of both species in greenhouse pots, and compared results under baseline conditions and epidemic rust conditions. Analysis showed that wild oat weight and reproductive output were significantly reduced by crown rust infection, while stipa weight was significantly higher in crown rust treated replicates than in uninfected replicates. This indicates that rust application shifts the competitive balance in favor of the stipa and away from the wild oats; however, this shift may not be large enough for stipa to "win" without other weed control measures against wild oats.

CONCLUSIONS: The results of this project indicate that it is possible to increase early rust build-up and spread on San Clemente Island using augmentative methods early in the season. We were successful in establishing an infection at least two weeks earlier than the beginning

of the natural rust infection in 1997 but not in 1998, and we observed a disease gradient outside of one plot in both years as a result of these infections. Consistent results for an extensive biocontrol effort on SCI may be hard to obtain, as infections seem highly dependent on weather fluctuations. Nonetheless, application of augmentative amounts of rust was effective in lowering wild oat yield and reproduction, both in the field and in the greenhouse. Effective long-term control of wild oats on this island, however, will require a sharper reduction in reproductive output.

SIGNIFICANCE: These studies investigated the feasibility of using crown rust of oat as a biocontrol agent for wild oats. Our results indicate that obligate pathogens such as crown rust hold some promise for controlling grassy weeds such as wild oats, but are probably best used in a suite of management tools including re-vegetation, or combination with other pathogens and /or insects. The information gained from these studies may be applicable to other pathogen/weed systems.

PUBLICATIONS AND ABSTRACTS:

Carsten, L.D., M.R. Johnston, L.I. Douglas, and D.C. Sands, 2000. A field trial of crown rust (*Puccinia coronata* f. sp. *avenae*) as a biocontrol agent of wild oats on San Clemente Island. *Biological Control,* in press.

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Carsten, L.D., Bruce Maxwell, M.R. Johnston, and D. C. Sands, 2000. The impact of crown rust (*Puccinia coronata* f. sp. *avenae*) on competitive interactions between wild oats (*Avena fatua*) and stipa (*Nassella pulchra*). *Biological Control*, submitted May 2000.

Carsten, Laura D., 1998. Evaluation of crown rust (*Puccinia coronata* f. sp. *avenae*) as a biocontrol agent for wild oats on San Clemente Island. Master's thesis, Montana State University, Bozeman, MT.

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Douglas, L.I., R. Petroff, J. Stone, C. Winchell, M. Johnston, K. Leonard, & D.C. Sands, 1996. *Puccinia coronata* as a possible biocontrol agent of *Avena* spp. on San Clemente Island. Phytopathology: 86(11), 15.